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Modelling and Simulation of a Company Inventory Using Arena Software

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Abstract: Typical inventory management systems used simple mathematical equations to determine order amount and time to order. In this study, Arena software is proposed as a modern tool for helping a company in solving inventory-related problems. This study aims to build a model of the company inventory system using Arena Simulation Software and to provide the analysis of the simulation result related to the inventory system. This study used modules from the Blocks and Elements panels from Arena Software to build the simulation model with the capability to analyze the inventory management. The model was verified by comparing the simulation result with the result from Kelton related to the values of daily holding cost, shortage cost, and ordering cost. The verification process showed that the model performed exactly the same as referenced model. A new model from small warehouse inventory was developed to test the capability of imitating a similar model analysis. The results showed that the value of crane utilization was 99.98%, average inventory level was 28.90, average total cost was $170.65 and 57 number of unfilled requests. This study can be used in the future to reduce total inventory expenses through simulation analysis, while also highlighting how simulation techniques can be effectively used to solve problems related to inventory management.

Keywords: Arena Simulation Software, Simulation Analysis, Inventory Management

1. Introduction

In the era of globalization, planning for inventory order quantity and order time of the products is an essential management strategy that impacts the total cost of a company and inventory management system. Inventory refers to the amount of any item or resource used in a company. An inventory system is a group of policies and procedures that monitor inventory levels and determine what levels should be maintained when stock should be refilled, and how large orders should be processed [1]. Bloated or high inventory levels have been a problem for companies. Poor forecasting, preliminary order and detailed product, poor production scheduling, low quality, bottlenecks, extended cycle times, and improper performance measurements can increase inventory.

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Predicting the behaviour of real systems for the purpose of planning or manipulating their behaviour to achieve a specific goal or address a specific problem is the primary goal of simulations. Controllable input values are chosen and probabilistic input values are created at random in a simulation experiment. In order to compute the output values, the model is first built utilizing the gathered data [2]. No optimization techniques are used in simulation, it is simply a tool to predict how a system will perform given specified conditions for the controllable inputs and randomly generated values for the probabilistic inputs [3].

There will be a cost for every action taken in inventory management, especially when the storage is too ample. When inventory is high, more space is required for storage, management, and handling of the item’s quality. As a result, the size of inventory depends on the demand. Demand is unpredictable, and it might be high, medium, or low at any time. In this study, the Arena software will manage the company inventory by simulation of its operations model. Arena software provides a method for analyzing the existing performance of the inventory process and any potential improvements. A company can see the outcomes of changes without applying them in real-time by precisely simulating a process, saving lots of time and resources [4].

2. Methodology

The aim of this study was to build a model of the company inventory system using Arena Simulation Software and to provide a detailed analysis of the simulation result related to the inventory system. Firstly, a literature review was conducted looking for information from previous studies relevant to this research. Then, the data was obtained for the modelling and simulation process. Finally, after obtaining the data needed, the model of company inventory was built. After all the development procedures, the simulation was run using the Arena Software. A detailed analysis of the inventory system's simulation result was provided from the simulation conducted earlier. This model was verified and validated by comparing the simulation result against the results from the referenced model. Furthermore, a new model was developed as an alternative model to show and test the knowledge gathered from the first model. During this study, the entire process was summarized in the results and discussion section before finalizing the conclusion.

2.1 Data Collection

Data collection is the process of gathering and analyzing relevant information in order to achieve the research, test hypotheses and evaluate results [5]. The data used for this study were obtained from the Simulation with Arena by Kelton [4]. The inventory data from Bucky company was used to simulate and model its operations inventory. Table 1 shows the data collected for this study.

Table 1: Data collected for this study

Variables	Values
Inventory level	60
Little s (minimum on hands inventory)	20
Big S (maximum on hands inventory)	40
Total ordering	Accumulator
Setup cost	32
Incremental cost	3
Unit holding cost	1
Unit shortage cost	5
Days to run	120

To begin, there were 60 devices of remote control available: $I(0) = 60$. The company counts inventory at the start of each day to decide whether to order with the device supplier. They placed an order to another constant S (S = 40) if the inventory level is below s (s = 20). This means that they ordered a certain number of the devices so that if they were to arrive right away, the inventory level would rise to the exact S. If the inventory level at the beginning of the day is I(t) and $I(t) < s$, then they order $S - I(t)$. Otherwise, if $I(t) \geq s$, they waited the next day to check. Systems like this were referred to (s, S) inventory models due to their structure. In this system, the company was interested in the average total running cost each day over 120 days.

In this system, the company was interested in the average total running cost each day over 120 days, which includes three components:

i. Average ordering cost per day

   It costs $32 per order plus an additional $3 for each item ordered every time an order was placed. If no orders were submitted, there was zero ordering cost. After the 120-day simulation, the average daily ordering cost was calculated by dividing the total by 120

ii. Average holding cost per day

   A $1 per remote control per day holding cost was applied whenever there were actual inventory items in stock ($I(t) > 0$). To sum it all up, the total holding cost was:

$$\int_0^{120} 1 \times max\ (I(t), 0)\ dt \qquad \text{Eq. 1}$$

   In this case, the average holding cost per day was the total of this holding cost divided by the length of the simulation, which was 120 days.

iii. Average shortage cost per day.

   Shortage costs of $5 per remote control per day were incurred whenever inventory was low ($I(t) < 0$). As a result, the total shortage cost was:

$$\int_0^{120} 5 \times max\ (-I(t), 0)\ dt \qquad \text{Eq. 2}$$

   Therefore, the daily average shortage cost per day can be calculated by dividing the sum of shortage costs by the simulation duration

The results of the model's simulation were analyzed to ensure that there were no errors or problems with the model [6]. This step was required to ensure that the modelling and simulation of the company inventory were effective.

3. Results and Discussion

Arena Software allows the simulation to be run after all data and information have been entered. The whole process was modelled, simulated and analyzed. Figure 1 shows the model of company inventory prepared using Arena Software. Before beginning the simulation, Arena does a model validity check to ensure the model is accurate [7]

After simulating the base model for 120 days, it can be seen that the number of available items in inventory decreases as new demands was placed, only to gradually increase again when new orders are filled. As shown in Figure 2, the expression MX(Inventory Level, 0) are plotted in black to represent increasing inventory while the expression MN(Inventory Level, 0) are plotted in red to represent decreasing inventory levels. Both plots are shown on the same graph.

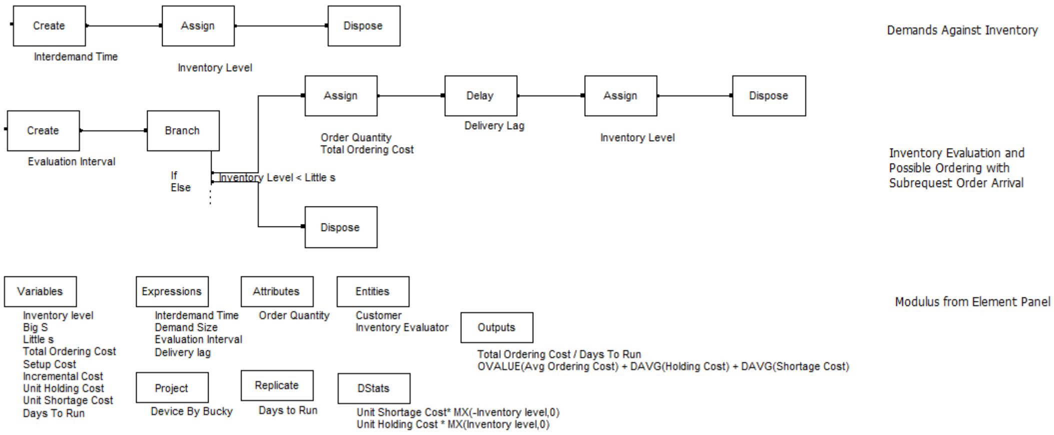


Figure 1: The complete inventory model

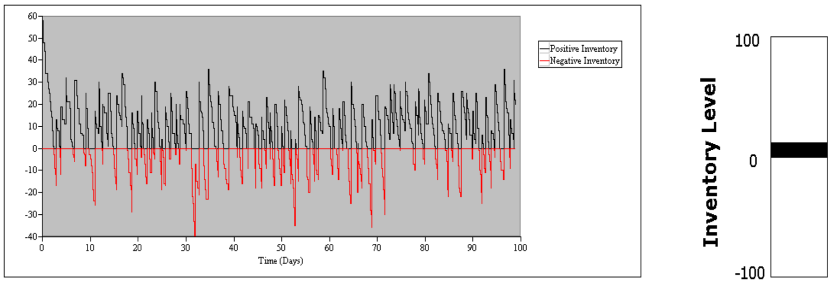
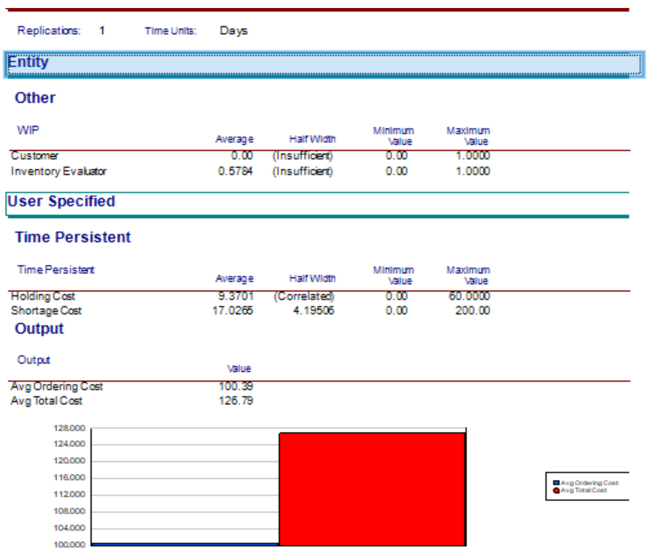


Figure 2: Inventory simulation

3.1 Simulation Results

When the simulation was completed, it produced a collection of statistics in a report called run results. The simulation results for each set of variables were used to determine the average daily costs for holding cost, shortage cost, and ordering cost. After running the simulation, the results that were obtained were shown in Figure 3. From the results, it can be seen that the average daily costs were \$126.79, with \$9.37 being spent on holding, \$17.03 on shortage, and \$100.39 on ordering.


Replications: 1 Time Units: Days

Entity

Other

WIP	Average	Half Width	Minimum Value	Maximum Value
Customer	0.00	(Insufficient)	0.00	1.0000
Inventory Evaluator	0.5784	(Insufficient)	0.00	1.0000

User Specified

Time Persistent

Time Persistent	Average	Half Width	Minimum Value	Maximum Value
Holding Cost	9.3701	(Correlated)	0.00	60.0000
Shortage Cost	17.0265	4.19506	0.00	200.00

Output

Output	Value
Avg Ordering Cost	100.39
Avg Total Cost	126.79

Figure 3: Simulation result

3.2 Validation and Verification

From Table 2 the difference between the result from the reference model and the simulated model was relatively small. Thus, both the simulation model and the result were accurate.

Table 2: Comparison of reference model and simulation

Parameter	Actual (Reference Model)	Simulation
Holding Cost	$9.37	$9.3701
Shortage Cost	$17.03	$17.0255
Average Ordering Cost	$100.39	$100.39
Average Total Cost	$126.79	$126.79

3.3 Development of a Small Warehouse Inventory

The purpose of developing this model was as an alternative model to show and test the knowledge gathered from the first model. A small warehouse was used to store work-in-process for a manufacturing facility that makes four different kinds of parts. The part-type percentages and inventory costs per part are shown in Table 3. Figure 3 illustrates the model of the small warehouse inventory. The model was run for 5,000 minutes with four of each part type initially stored in the warehouse. After running the simulation, the results are shown in Figure 4. The results of the simulation for each set of variables were used to determine crane utilization, the average inventory level, the average total cost and the number of unfilled requests.

Table 3: Parameter of the small warehouse inventory

Part Type	Inventory Cost	
	Percentage	Per Part
1	20	$5.50
2	30	$6.50
3	30	$8.00
4	20	$10.50

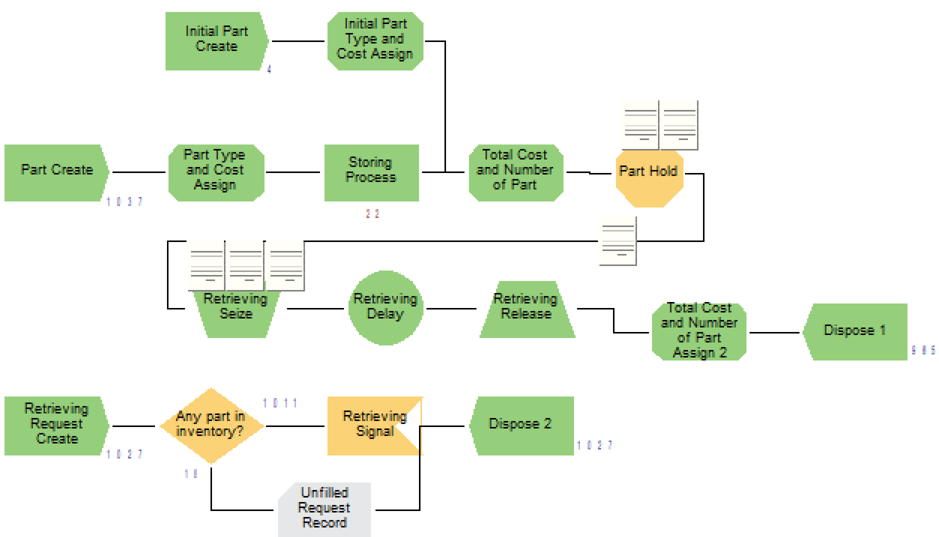
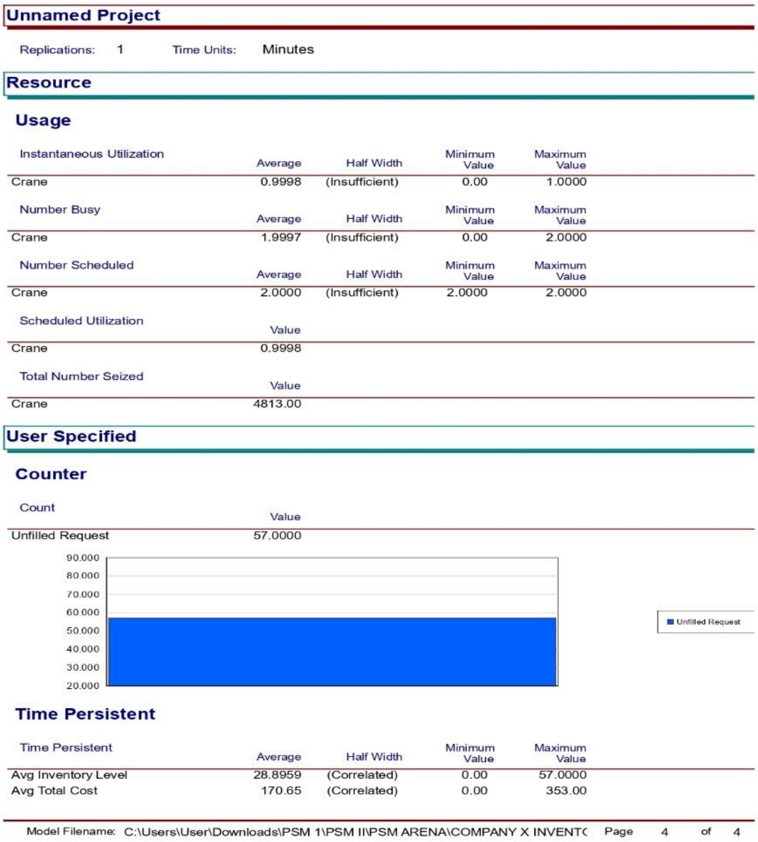


Figure 3: The model of the small warehouse inventory



Unnamed Project

Replications: 1 Time Units: Minutes

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
Crane	0.9998	(Insufficient)	0.00	1.0000

Number Busy	Average	Half Width	Minimum Value	Maximum Value
Crane	1.9997	(Insufficient)	0.00	2.0000

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
Crane	2.0000	(Insufficient)	2.0000	2.0000

Scheduled Utilization	Value
Crane	0.9998

Total Number Seized	Value
Crane	4813.00

User Specified

Counter

Count	Value
Unfilled Request	57.0000

Time Persistent

Time Persistent	Average	Half Width	Minimum Value	Maximum Value
Avg Inventory Level	28.8959	(Correlated)	0.00	57.0000
Avg Total Cost	170.65	(Correlated)	0.00	353.00

Model Filename: C:\Users\User\Downloads\PSM 1\PSM II\PSM ARENA\COMPANY X INVENT(Page 4 of 4

Figure 4: Result of the simulation

The summary of the results that were obtained are shown in Table 4.

Table 4: Collected statistic result

Parameter	Result
Crane Utilization	99.98%
Average Inventory Level	28.90
Average Total Cost	$170.65
Number of Unfilled Request	57

From Table 4, the value of crane utilization was 99.98%, average inventory level was 28.90, average total cost was 170.65 and 57 number of unfilled requests. The results of this study can serve as a guide for any decisions that need to be made by companies in the future.

4. Conclusion

In conclusion, this study achieved all the objectives which are to build a model of the company inventory system using Arena Simulation Software and provide a detailed analysis of the simulation result related to the inventory system. The study showed how simulation analysis could be utilized for inventory analysis and later may be used for optimization. The Arena Software has compared the result from reference data and the simulation that has been run. The inventory management technique can help industries save costs and improve the efficiency of the management process.

Realizing the benefits of simulation to imitate a real-world system, this study used Arena simulation software as a modern tool for helping the company in solving inventory-related problems. The simulation process is more efficient than directly implementing any adjustment to the existing system. On top of that, the outcome may be seen immediately, making it much simpler for the analyst to choose the course of action required. This technique is proven to save time and cost based on research completed by an expert.

Acknowledgement

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